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Distribution, Movements and Size Composition of Spring-Spawning Herring in the Northern Gulf of St.Lawrence

by

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Abstract

The abundance of the 4R spring-spawning herring stock in St. George's Bay and Port-au-Port Bay has been in decline since 1987. However, several observations suggest that spring-spawning herring are plentiful in other areas in the north-eastern Gulf of St. Lawrence, especially in the late-fall Bonne Bay / Bay of Islands fishery. Using both commercial and research data, the distribution and movements of the spring-spawning herring in the north-eastern Gulf are described. These analyses revealed that the distribution and relative strength of the various dominant year-classes (1980, 1982, 1987, 1989) changes throughout the year. The 1980 and 1982 year-classes were almost always present in both the inshore and offshore catches. However, the 1987 and 1989 year-classes were poorly represented in the inshore near the spawning grounds, but were dominant in the offshore and in the late-fall fishery. The most probable explanation for this distributional pattern is that many of the spring herring from the 1987 and 1989 year-classes caught along the west coast of Newfoundland are local spawners from the Quebec lower north shore which migrate to 4R in the fall.

Résumé

La composante des frayeurs de printemps du stock de hareng de 4R dans la Baie St-Georges et celle de Port-au-Port a décliné depuis 1987. Toutefois, plusieurs observations suggèrent que les frayeurs de printemps sont abondants en d'autres régions dans le nord-est du Golfe du St-Laurent, spécialement dans les pêcheries tardives d'automne de Bonne Bay et de Baie des Iles. Les distributions et déplacements de cette composante du stock dans le nord-est du Golfe sont décrits en utilisant à la fois les données commerciales et de recherche. Ces analyses révèlent que la distribution et la force relative des différentes classes d'âge dominantes (1980,1982, 1987, 1989), varient au cours de l'année. Les cohortes 1980 et 1982 furent presque toujours présentes à la fois dans les captures côtières et hauturières. Toutefois, les classes d'âge 1987 et 1989 furent faiblement représentées dans les captures côtières près des frayères, mais furent dominantes dans la pêche hauturière et dans la pêche tardive d'automne. Ce patron de distribution s'expliquerait par le fait que plusieurs frayeurs de printemps des cohortes 1987 et 1989 capturés le long de la côte ouest de Terre-Neuve, sont des frayeurs locaux provenant de la Basse Côte-Nord du Québec migrant vers 4R à l'automne.

Introduction

Since 1993, the 4R herring stock assessments have shown the abundance of the spring-spawning stock to be in decline (McQuinn and Lefebvre 1993, 1994). This decline has been most strongly felt by the inshore sector in St. George's Bay and Port-au-Port Bay as witnessed by the widespread comments to this effect by fishermen in these areas (Figure 1). Catch rates estimated from index fishermen from all around the St. George's Bay / Port-au-Port Bay area have confirmed the decrease in abundance of the spawning concentrations of spring herring in southern 4R (Figure 2a). Opinions from the inshore sector point mainly to overfishing as the cause for the decline (Table 1). It is true that fishing effort has been concentrated on pre-spawning spring herring in St. George's Bay since 1988. On average, 10,700 t or 66% of the total annual purse seine catch has been harvested annually from these southern spawning areas since 1989. However, the 1994 stock assessment showed that the fishing mortality of spring-spawning herring was only slightly above the $F_{0.1}$ target of 0.3 (McQuinn and Lefebvre 1994), indicating that total fishing mortality on the stock was not excessive.

At the same time, the autumn-spawning stock has been only lightly exploited over the past 10 years and has also received a recruitment boost from the moderately strong 1986 year-class. Although most analyses indicate that this stock is quite healthy, (McQuinn and Lefebvre 1995), the dominant 1986 year-class is now 9 years old and has passed its peak biomass, and should also be in decline in 1995. This is reflected in the index-fisherman catch rates (Figure 2b) which peaked in 1992 and has since declined, although the stock biomass has most likely declined less abruptly than these catch rates suggest (for a further discussion of the commercial fishing data, see McQuinn and Lefebvre 1995).

There are therefore several indications that the spring-spawning stock is presently at a low biomass while the autumn spawning stock is considerably more healthy. However, seiner operators contend that concentrations of herring are abundant, especially in the late-fall Bonne Bay / Bay of Islands fishery. Further, biological sampling confirms that a relatively high proportion of spring spawners are caught in this, as well as other late-fall fisheries all along the coast. This would not be expected if the spring-spawning stock was critically low. This ambiguity has lead to a detailed look at the distribution, movements and size composition of the spring-spawning herring caught in western Newfoundland.

Distribution and Movements of Spring-Spawning Herring in 4R

Commercial data

The distribution and movements of the spring-spawning herring along the west coast of Newfoundland can be followed to some extent from the biological samples of both commercial and research catches which are collected annually by DFO. Intensive sampling in 1994 also allowed us to determine the proportion of spring and autumn spawners in previously under-sampled areas. A summary of the proportions of spring spawners versus autumn spawners by month and fishing zone for the three main fishing gears over the past 10 years (Figures 3-5) shows how the percentage of spring spawners varies in the catches depending upon where and when one fishes, and with what gear. These data have been summarised by fishing zone, month and gear for 1994 (Table 2) although where no

samples were available, data from previous years were used. The changing percentages are governed by the relative abundance of both spring and autumn spawners, their annual movements, as well as the selectivity of the different gears.

Several patterns can be discerned from these data, e.g. the main spawning areas for both stocks can be identified. Spring spawning occurs in 4Rc and 4Rd, from April to June as all gear sectors catch a high percentage of spring spawners (80-100%) in spawning condition in these southern zones in the spring. Similarly, autumn spawning is concentrated in 4Ra from July to September as a high proportion of this spawning stock is found in the catches of all gear types at this time, although more so for the gillnets who fish closer to the spawning grounds. In other zones at other times of the year the proportions can be quite variable. Herring concentrations in the late fall are traditionally mixed in Bonne Bay (4Rb) and Bay of Islands (4Rc). For instance, in the late fall (October-November) when schools are migrating, the proportion of spring spawners in 4Rb and 4Rc has ranged from a low of 30% to a high of 80% (Figure 3) although there is a trend towards fewer spring spawners in this fishery in November since 1987.

Research Data

Although it is possible to make out general patterns from these data, it is nonetheless difficult to follow the movements of these herring stocks solely from commercial fishing data. Sampling from the fixed gear sector provides valuable information on spawning concentrations and inter-annual variations in spawning intensity and abundance, but little information on movements outside the spawning season. On the other hand, the mobile gear sector can provide much more information on movements and incoming year-classes, but often these data are very localised, and concentrated close to ports of landing.

Significant amounts of herring are encountered outside known fishing areas during research surveys and by commercial vessels fishing other species. Research surveys conducted by DFO for groundfish and pelagic species can reveal certain herring distributional patterns, especially in offshore areas. The annual January bottom-trawl survey has consistently caught herring below 100 fathoms within the Esquiman Channel (Figure 6). These herring are a mixture of spring and autumn spawners (Figure 7) which are either overwintering in deeper, more stable waters, having left the colder coastal zones or are migrating southward towards the southern entrance to the Gulf.

In early May of 1994, another bottom-trawl survey encountered herring concentrations again below the 100-fathom contour at the same time that the spring fishery was getting under way in St. George's Bay (Figure 8). These herring were again a mixture of spring and autumn spawners, although the proportion of spring spawners increased towards the north (Figure 9). In the inshore, spring spawners were highly dominant in May and June, with autumn spawners dominating from July to September, except in the Esquiman Channel and the Bay of Islands. In October and November, schools were again mixed along the coast.

Size Composition of Spring-Spawner Catches

Length frequency data showed that over the last 5 years both gillnets and purse seines continue to fish predominantly the 1980 and 1982 year-classes in the St. George's Bay (4Rd) spring fishery (Figures 10-12). These year-classes have been the major component of the catches in this area since 1983 (11 years), with only a minor contribution from the 1987 year-class. However, samples taken from purse seine catches from later in the year (mainly from September to November) in the more northerly zones (4Ra-4Rc) showed the 1987 and even the 1989 year-classes to be much more abundant than in 4Rd (Figures 10-11). Similarly, it was noted from the gillnet size composition (Figure 12) that the 1987 year-class was also better represented in the northern zones, although more so in some years than in others. However, these histograms combine data for all months. When the gillnet size compositions for areas 4Ra and 4Rb are presented separately for the spring/summer versus fall/winter seasons (Figure 13), the 1987 year-class has also been absent in the spring inshore catches in northern 4R since 1990.

The importance of the 1987 and 1989 year-classes has also been noted since 1990 in research bottom-trawl and pelagic-trawl surveys conducted nearshore and offshore in January, May and November/December (Figures 14-16). These year-classes have been dominant in 4Rc during the winter survey since 1993 and in all zones during the late fall survey since 1990.

A more detailed examination of these spring-spawner size compositions from all available sources in 1994 revealed that the distribution of the various dominant year-classes changes throughout the year. Starting in January (Figure 17), the larger individuals (1980/1982 year-classes) were found towards the northern end of the Esquiman Channel, while the medium-sized individuals (1987/1989 year-classes) were southeast of Beaugé Bank. Although catches were modest, the smallest individuals (1991 year-class) were in the southern areas off St. George's Bay.

In May, although the entire Esquiman Channel was not surveyed, the 1987/1989 year-classes were dominant among the spring spawners offshore throughout the southern end of the channel, while the 1980/1982 year-classes were dominant inshore where spawning was occurring (Figure 18). This pattern can be at least partially confirmed by a number of shrimp-trawl samples taken in May and June of 1993 (Figure 16), showing that the 1987/1989 year-classes were relatively abundant in deeper waters at the northern end of the channel as well. Therefore, although the 1987 year-class was well represented in the Esquiman Channel in January and again in May, significant numbers of this year-class have not spawned in southern 4R, even though most of them have been mature since 1991.

Discussion

It appears therefore that the decline in the spring-spawning component in the St. George's Bay / Port-au-Port area has come about mainly from two factors (1) the lack of strong recruitment by the 1987 and 1989 year-classes to the spawning grounds combined with (2) the concentration of fishing effort in this area since 1988. Although the 1987 and 1989 year-classes appear to be present in abundance in the northern Gulf in both the research surveys and the late-fall fisheries, they have not been detected spawning in abundance along the west coast of Newfoundland.

There are two possibilities which could explain these observations: (1) either there are other major spring-spawning areas in western Newfoundland which are presently unknown to both us and industry where the 1987 and 1989 year-classes have been spawning, or (2) many of the spring herring from these year-classes observed in the Esquiman Channel and along the west coast in the late fall originated from another areas in the northern Gulf. An examination of the size composition from the inshore fishery along the lower north shore of Quebec (4Sv and 4Sw) shows that the 1987 year-class has been present on the spawning grounds since 1992 and has been dominant since 1993 (Figure 19). Given the presence of the 1987 and 1989 year-classes in the Esquiman Channel in January, and again in May, these may well be herring migrating to 4S where spring spawning occurs in late May and June. This is the first indication of different year-class strengths between local spring spawners in 4R and those along the lower north shore of Quebec. Previous studies showed relative year-class strength to be similar between the two regions (Trudeau and McQuinn 1986).

From the data presented here, we can therefore ascertain the probable migration pattern of spring- and autumn-spawning herring in the north-eastern Gulf of St. Lawrence (Figure 20). In the early spring (April) the mixed schools, which have spent the winter in the deep waters of the Esquiman Channel, begin to move northward and inshore following the receding ice cover. The spring spawners head towards the spawning grounds in the bays while the autumn spawners are concentrated on schools of krill and copepods to replenish their fat reserves. Around the month of July, both spawning components head towards the northern end of the Gulf (Strait of Belle Isle) either to spawn, in the case of the autumn component, or to the summer feeding areas, in the case of the spring spawners. In the late fall (October to December) there is a concentration of all the various spawning components (spring and autumn, 4S and 4R) along the west coast of Newfoundland, but particularly around Bonne Bay where a major fall fishery takes place. Finally, as these waters cool at the onset of winter, these large schools leave the coast, often rather abruptly, to overwinter in the more stable and deep waters of the Esquiman Channel.

Conclusions

It appears therefore that although there are significant quantities of herring along western Newfoundland, the recruiting year-classes are not distributed equally along the coast. The 1987 and 1989 year-classes have not recruited strongly to the St. George's Bay spawning grounds, which has resulted in a notable reduction of herring biomass available to the inshore sector. Without a strong recruitment pulse, the abundance of the spring-spawning herring in the St. George's Bay / Port-au-Port area will not improve within the short term.

If, as suspected, the majority of the 1987 and 1989 year-classes are local 4S spawners, the definition of 4R as a management unit must be revised. Although there is no indication that local 4R herring are caught in other management units, it would be appropriate to expand the 4R management unit to include the Quebec lower north shore (northeast of Beaugé Bank) if indeed the herring which spawn along that shore are subsequently caught along the west coast of Newfoundland. Although available data does not allow us to affirm at this point that these two stock units should be combined, our research efforts will be oriented towards verifying this hypothesis.

Acknowledgements

We would like to acknowledge the contributions made by Jocelyne Hudon and Karine Kabasha for their diligent and expert assistance with the collection and compilation of much of the raw data, and the fisherman and port samplers (Jerry Lavers and Phil West) of the west coast of Newfoundland who provided us with biological samples, logbook and questionnaire information and many useful insights regarding the population dynamics of 4R herring.

References

McQuinn, I.H. and L. Lefebvre. 1993. An assessment of the west coast of Newfoundland (NAFO division 4R) herring resource up to 1992. DFO Atl. Fish. Res. Doc. 93/53, 48 p.

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McQuinn, I.H. and L. Lefebvre. 1995. A review of the west coast of Newfoundland (NAFO division 4R) herring fishery data up to 1994. DFO Atl. Fish. Res. Doc. 95/56.

Trudeau, C. and I.H. McQuinn. 1986. Fishery and biological characteristics of the 4S herring stocks in 1985. CAFSAC Res. Doc. 86/77, 23 p.

Table 1. Number of comments received from questionnaires sent to inshore herring fishermen along the west coast of Newfoundland in 1994.

COMMENTS	3Pn	4Rd	4Rc	4Rb	4Ra	TOTAL
Herring abundant	1	1		4	9	14
- during summer-fall	1			2	9	12
- due to DFO control				1		1
Herring stock in decline	4	21	13	25	9	71
- during spring				1		1
- during fall		1				1
Complaints against seiners:	1	19	16	20	23	78
- catch everything, destroying	1	16	13	16	18	63
- on spawning grounds		6	5	5	4	20
- dumping at sea	1		3	6	10	20
Others causes suggested:		4	6	2	3	15
- draggers		1	1	2	1	5
- Russian vessels (OSS)		2	2		1	5
- seals			2		1	3
- no food for herring		1				1
- gillnets negligent			1			1
Spawning:						
- in decline		2		1	1	4
- late arrival on grounds				2		2
- absence of spawn in fish				1		1
- increasing					1	1
- herring full of spawn		1			1	2
Size of herring:						
- small		7	6	7	9	28
- big			1	3	6	10
Distribution:						
- Herring offshore			1		1	2
- Herring inshore			1			1
Poor markets	1	2	5	2	34	43
Number of questionnaires received	17	54	55	103	144	373 (42%)

Table 2 Percent spring-spawning herring (by weight) from commercial samples collected in 1994 (unless otherwise indicated) by gear, zone and month.

LARGE PURSE SEINES													
ZONE		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
	4RA							[1] 23					
	4RB				[1] 35			39	11	41	32	51	
	4RC						90	[4] 68	27	66	52		
	4RD				[6] 90	92					39		
SMALL PURSE SEINES													
ZONE		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
	4RA											37	
	4RB					[5] 100			9	28	33		
	4RC					92	99	[4] 72		37	58	53	
	4RD				[6] 89	100					43		
GILLNETS													
ZONE		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
	4RA						[6] 85	7	1	11	[7] 24	[3] 41	
	4RB									[4] 37	[4] 42	[4] 43	
	4RC				[2] 83	93	88	[8] 31					
	4RD				[1] 98	97	99						

[1] 1988 [5] 1992
[2] 1989 [6] 1993
[3] 1990 [7] 1990 1992
[4] 1991 [8] 1990 1994

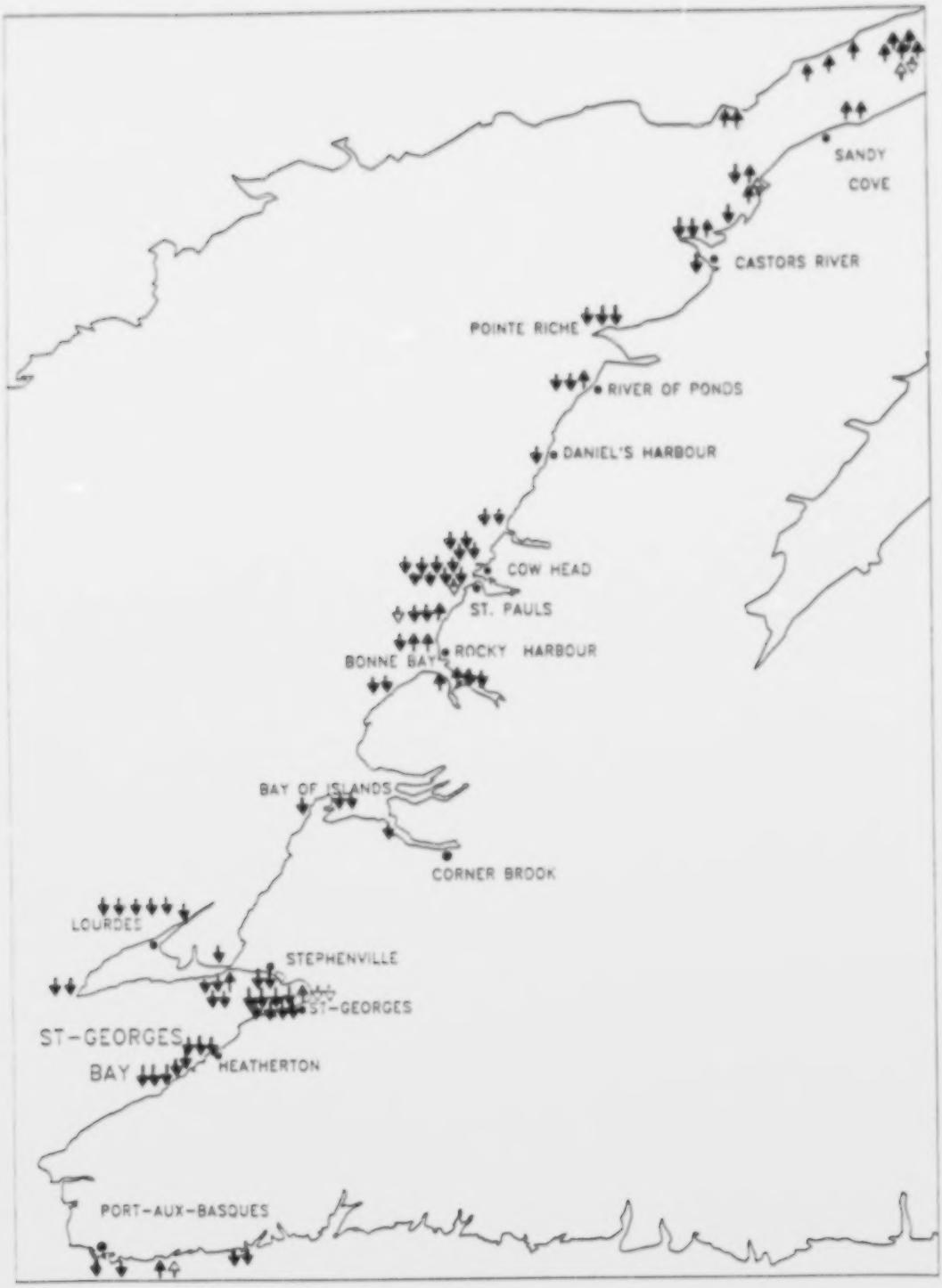


Figure 1. Distribution of inshore fishermen's opinions concerning the state of herring stocks and spawning in NAFO division 4R from 1994 written questionnaires [♠ = stock in good shape, ♦ = stock in decline, ♤ = good spawning, ♢ = spawning in decline].

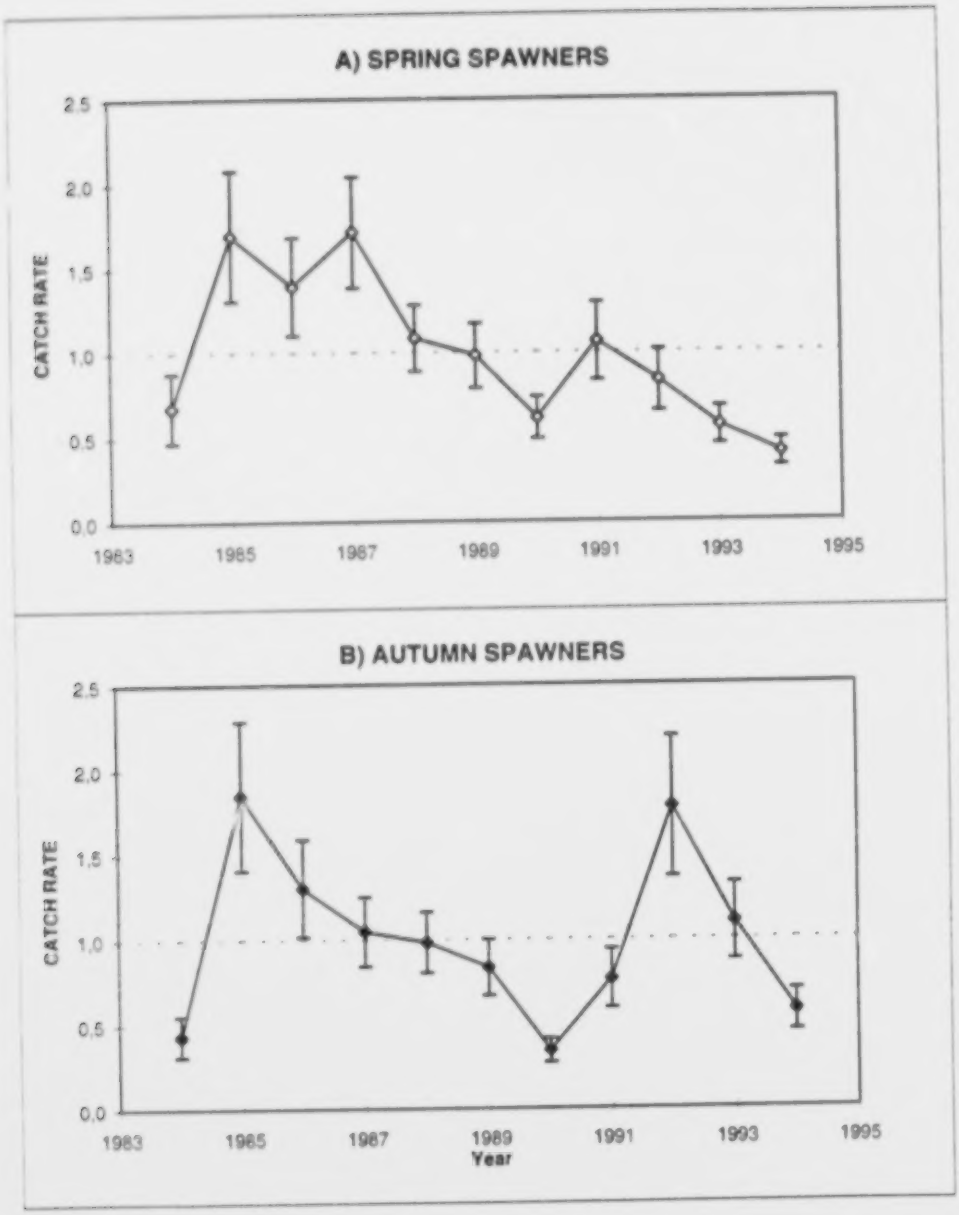


Figure 2. Standardized gillnet catch per unit effort and 2xS.E. for a) spring- and b) autumn-spawning herring in NAFO Division 4R as calculated from index-fisherman logbook data.

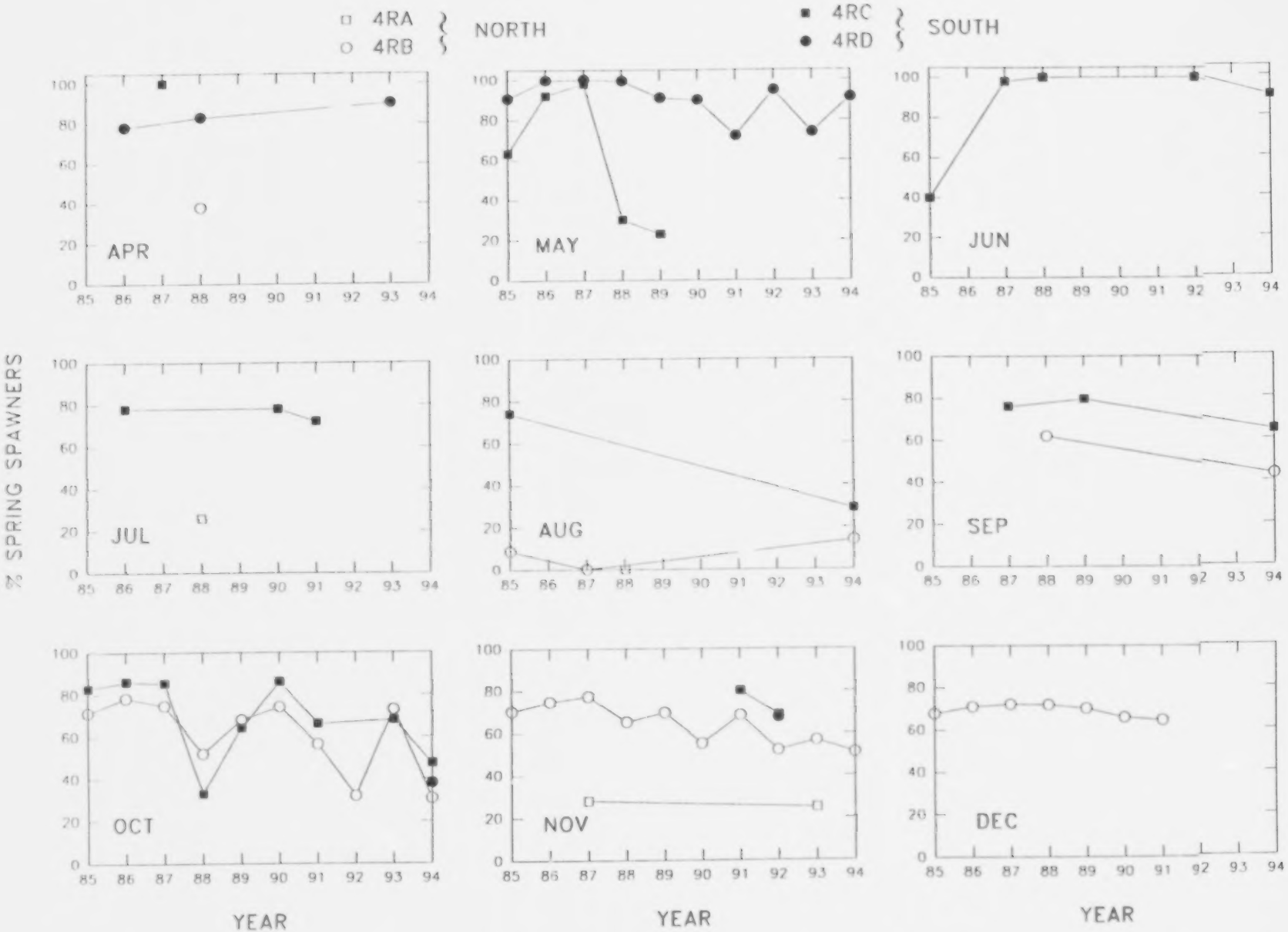


Figure 3. Percent spring–spawning herring by month, fishing zone and year estimated from large purse–seine commercial catches.

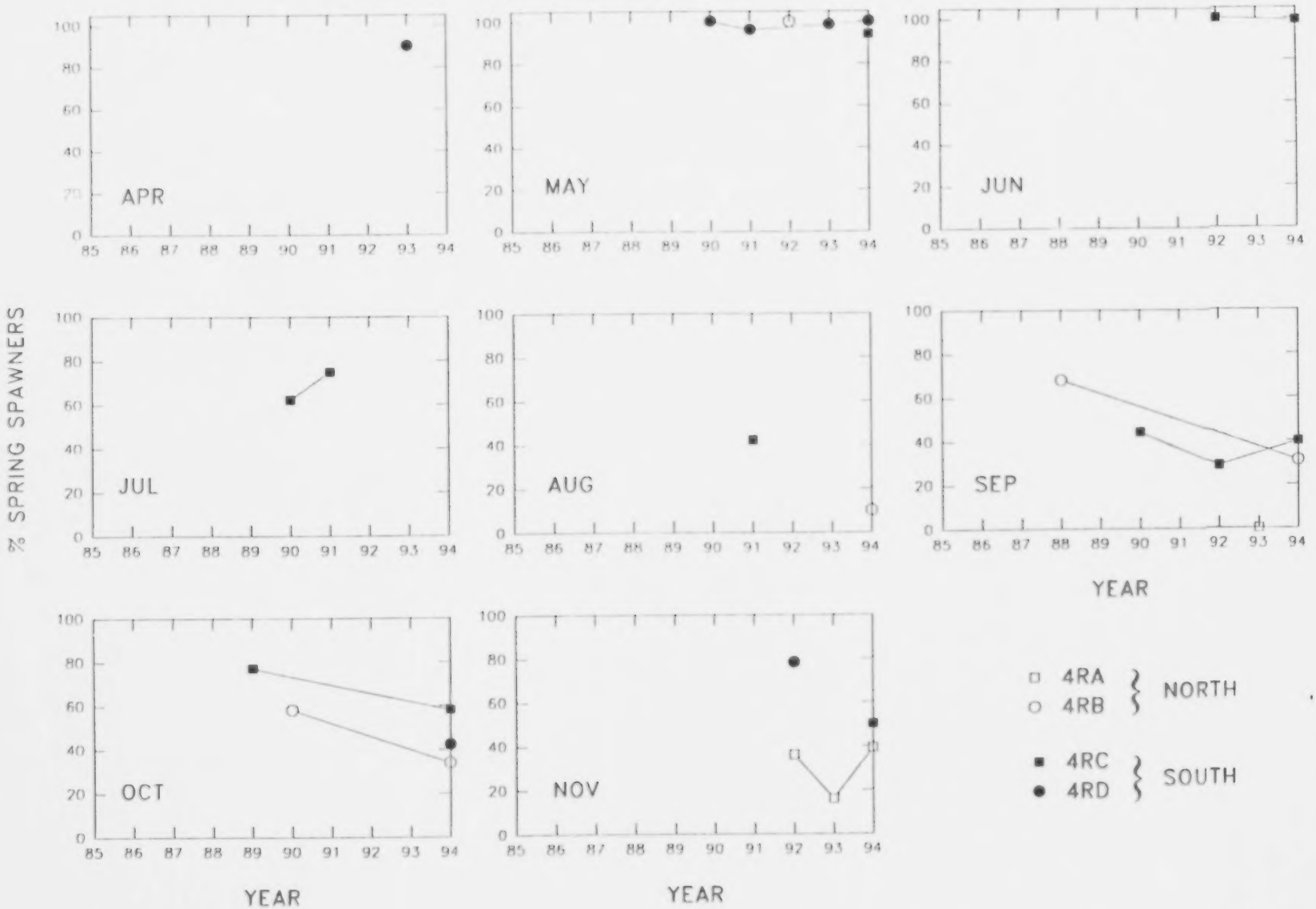


Figure 4. Percent spring–spawning herring by month, fishing zone and year estimated from small purse–seine commercial catches.

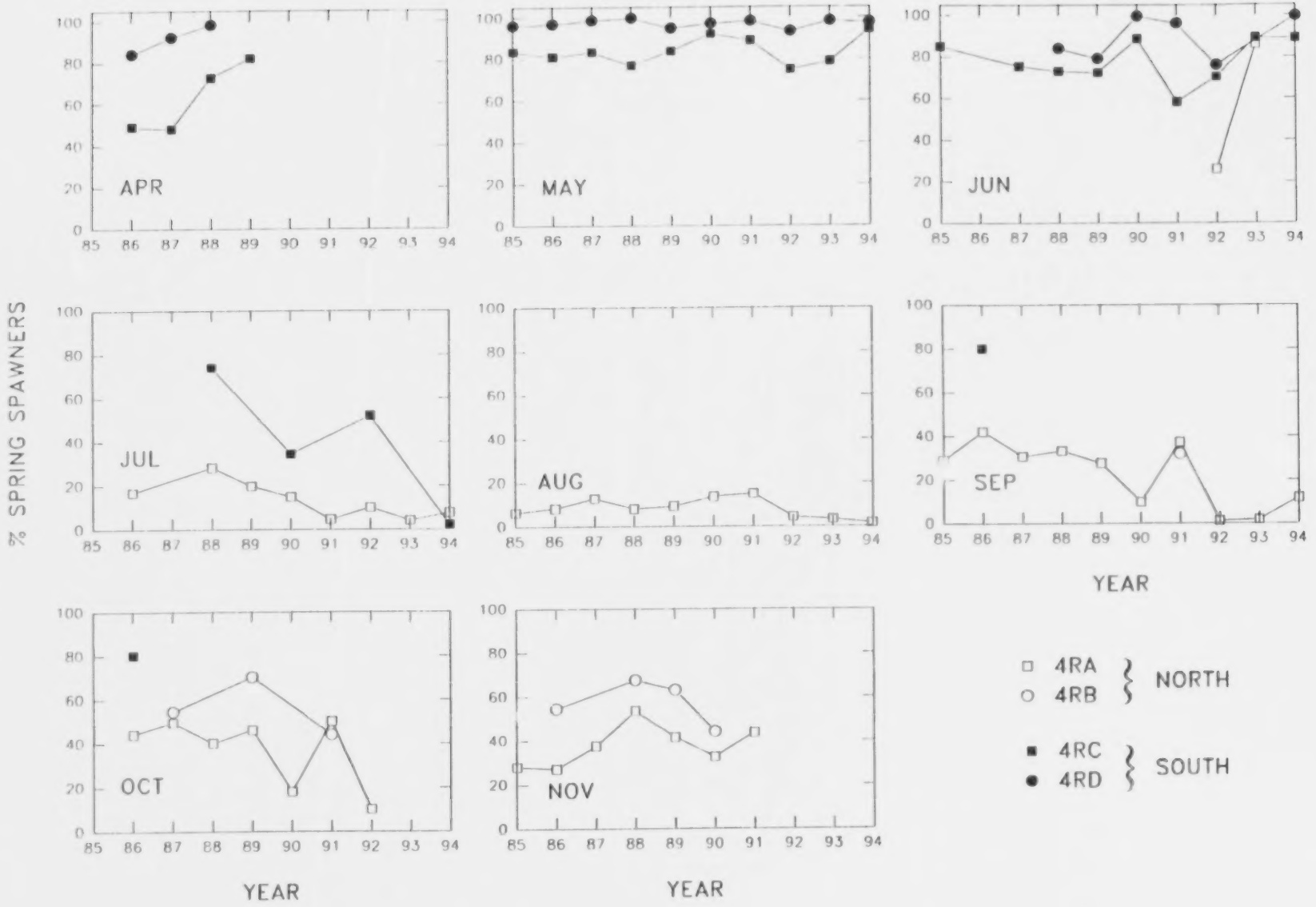
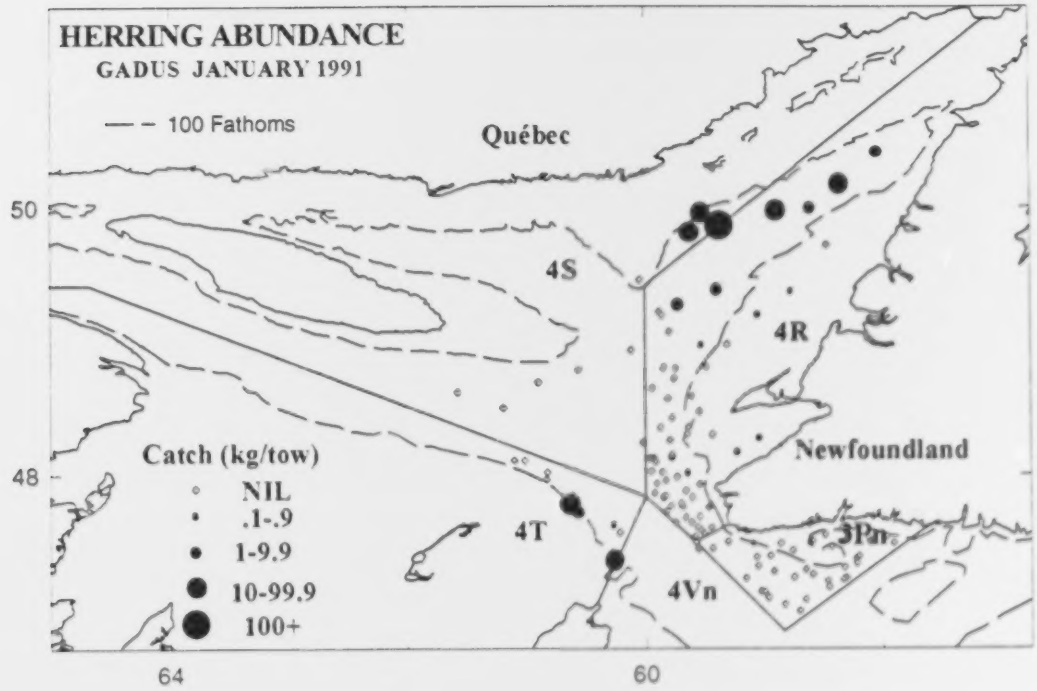


Figure 5. Percent spring–spawning herring by month, fishing zone and year estimated from gillnet commercial catches.



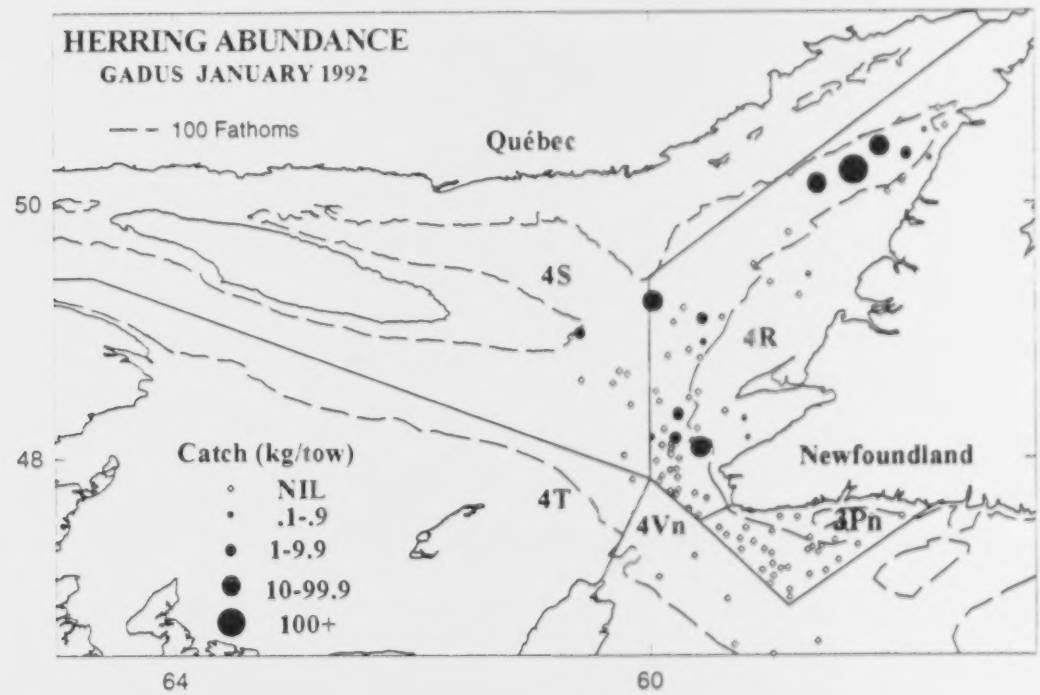
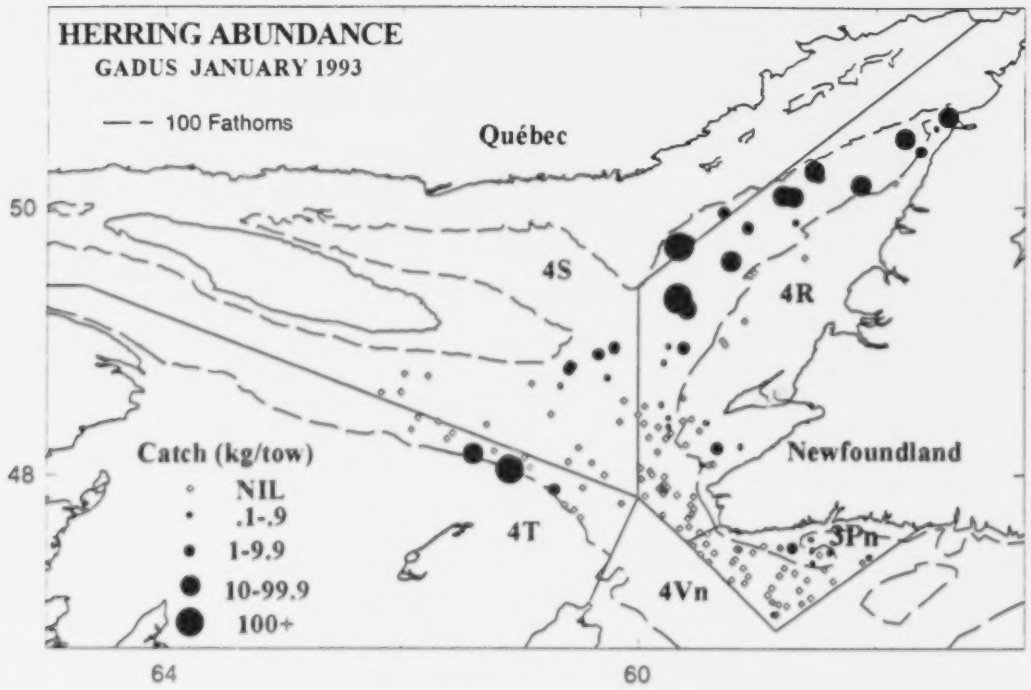


Figure 6. Distribution of herring catches from the *Gadus Atlantica* winter bottom-trawl survey from 1991 to 1994 in the Gulf of St. Lawrence.



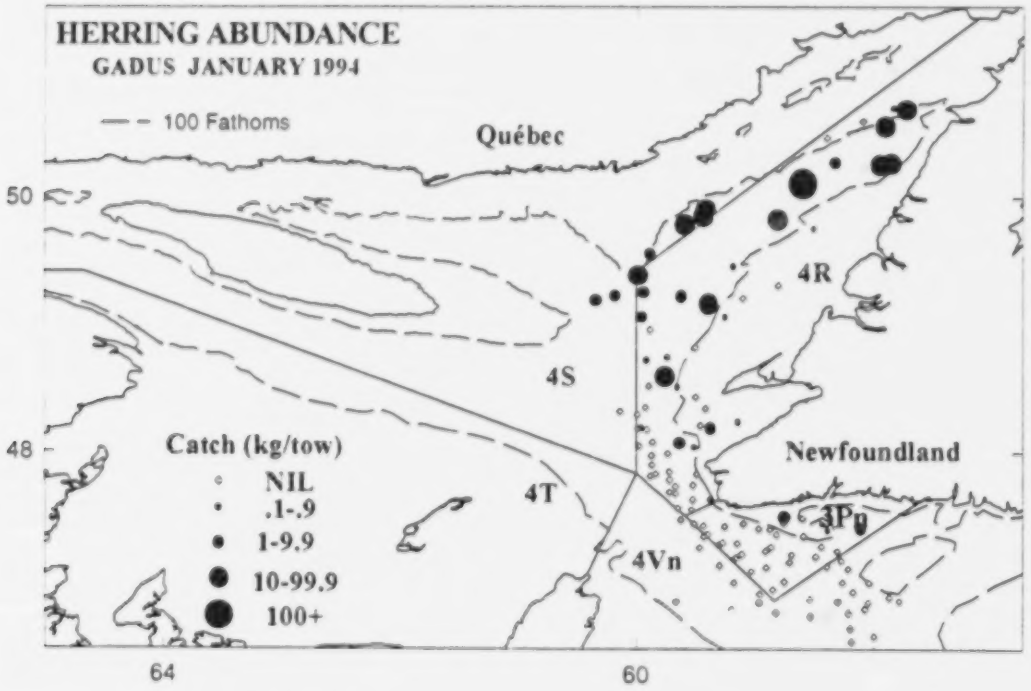


Figure 6. (Con't).

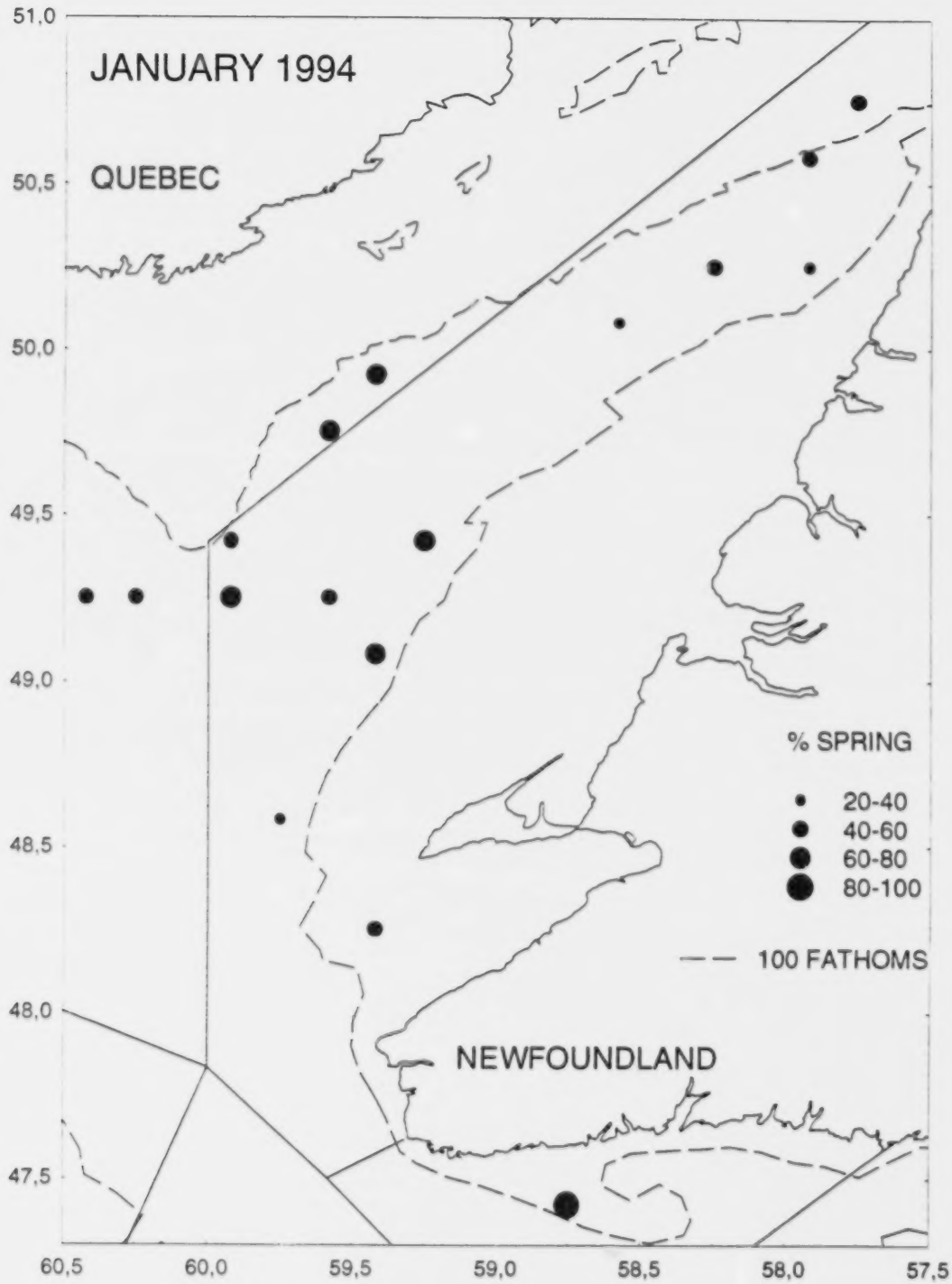


Figure 7. Percent of spring spawning herring by 10 minute squares from the *Gadus Atlantica* bottom-trawl survey in January, 1994.

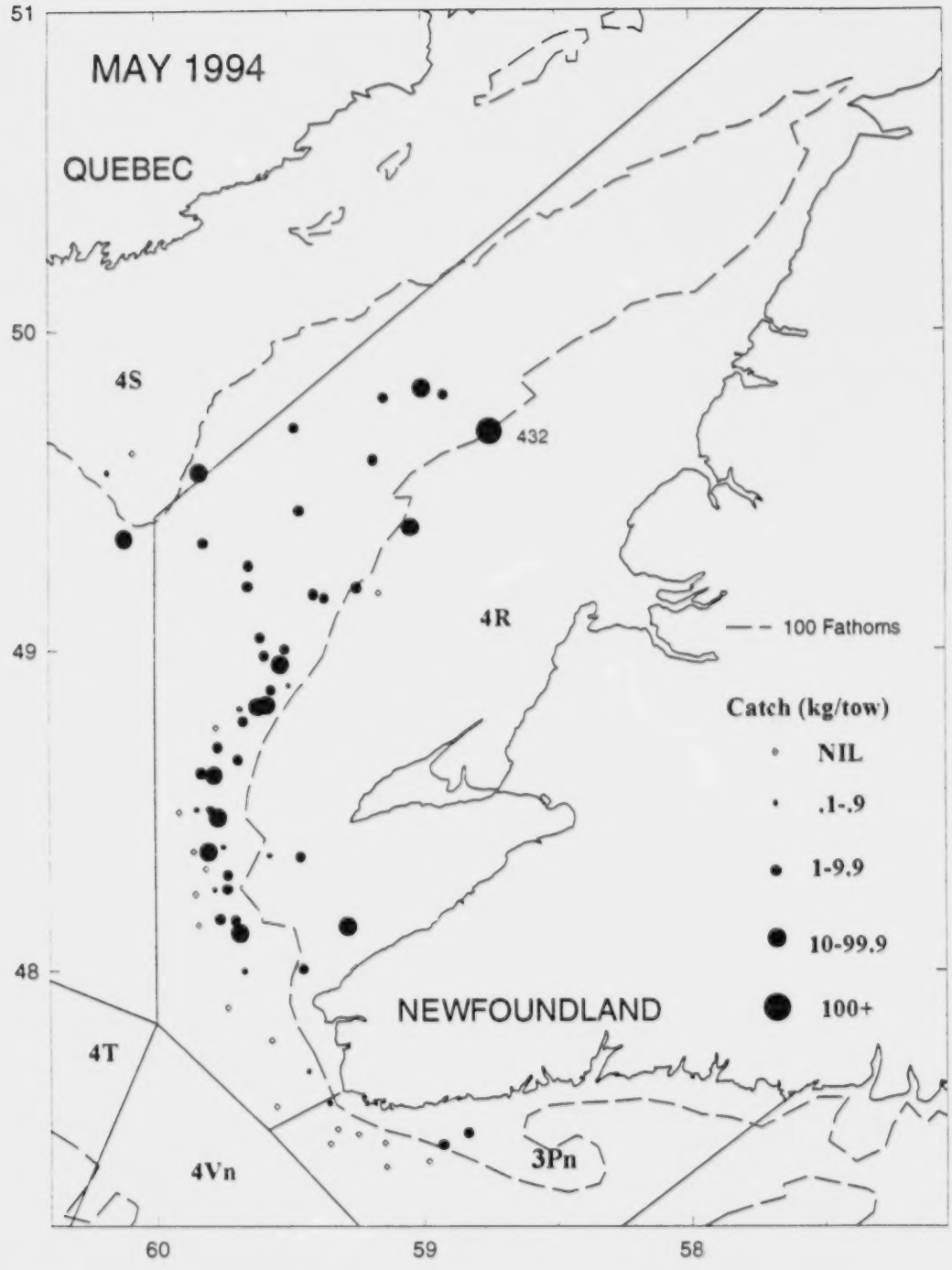


Figure 8. Distribution of herring catches from the *Gadus Atlantica* bottom-trawl survey in May, 1994 in the Gulf of St. Lawrence.

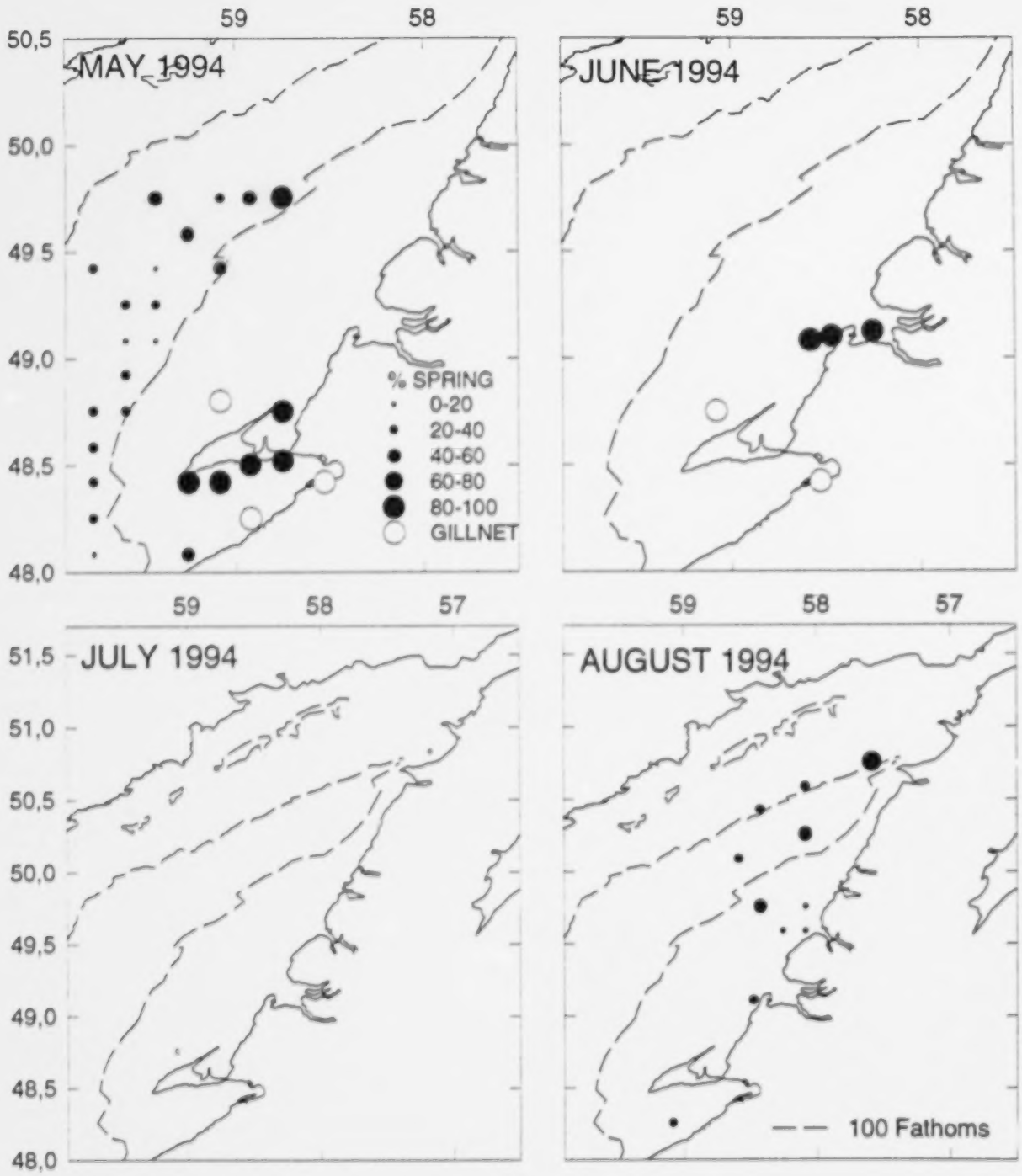


Figure 9. Percent of spring spawning herring by 10 minute squares from may to november from all commercial and research data collected in 1994.

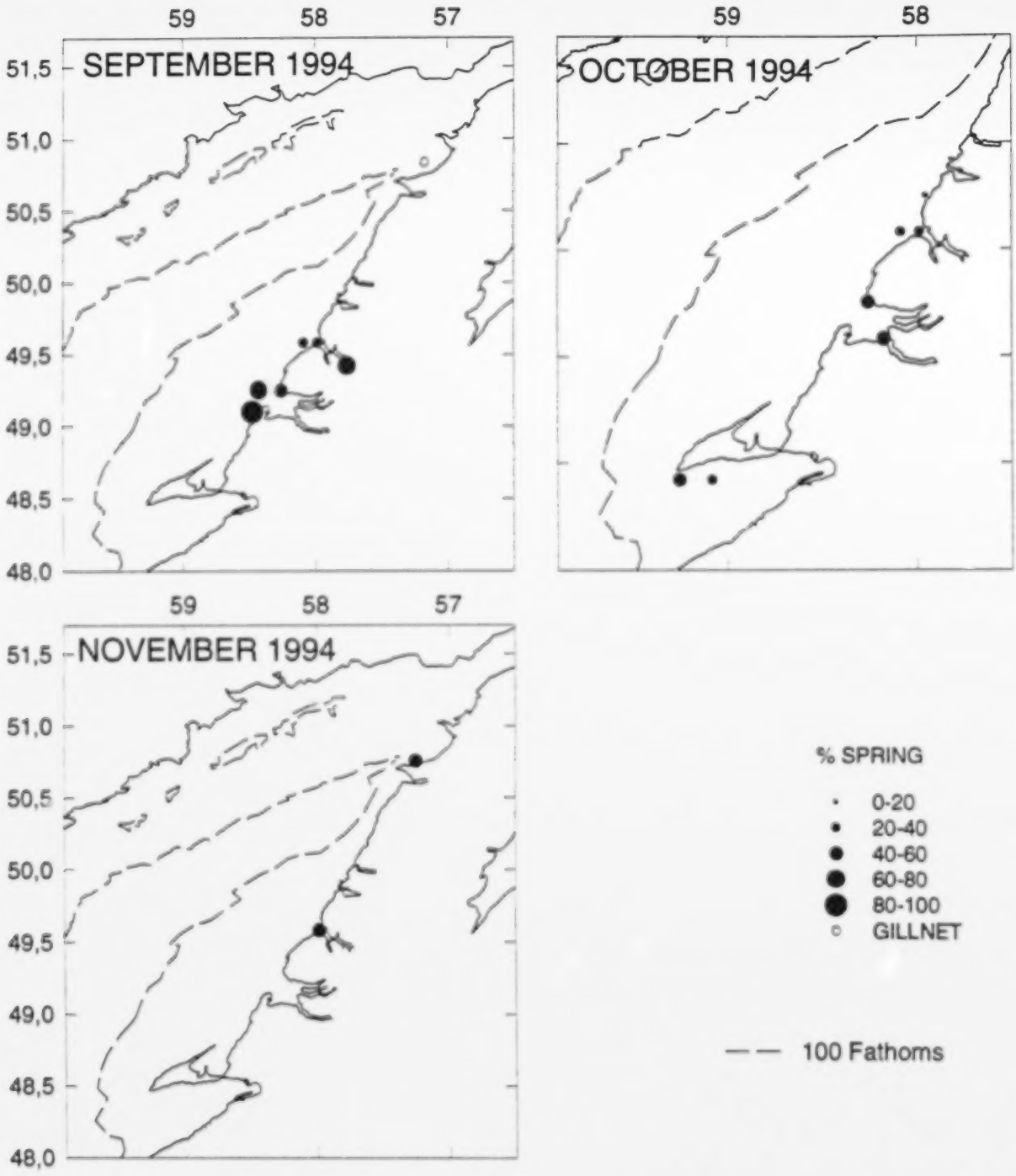


Figure 9. (Con't).

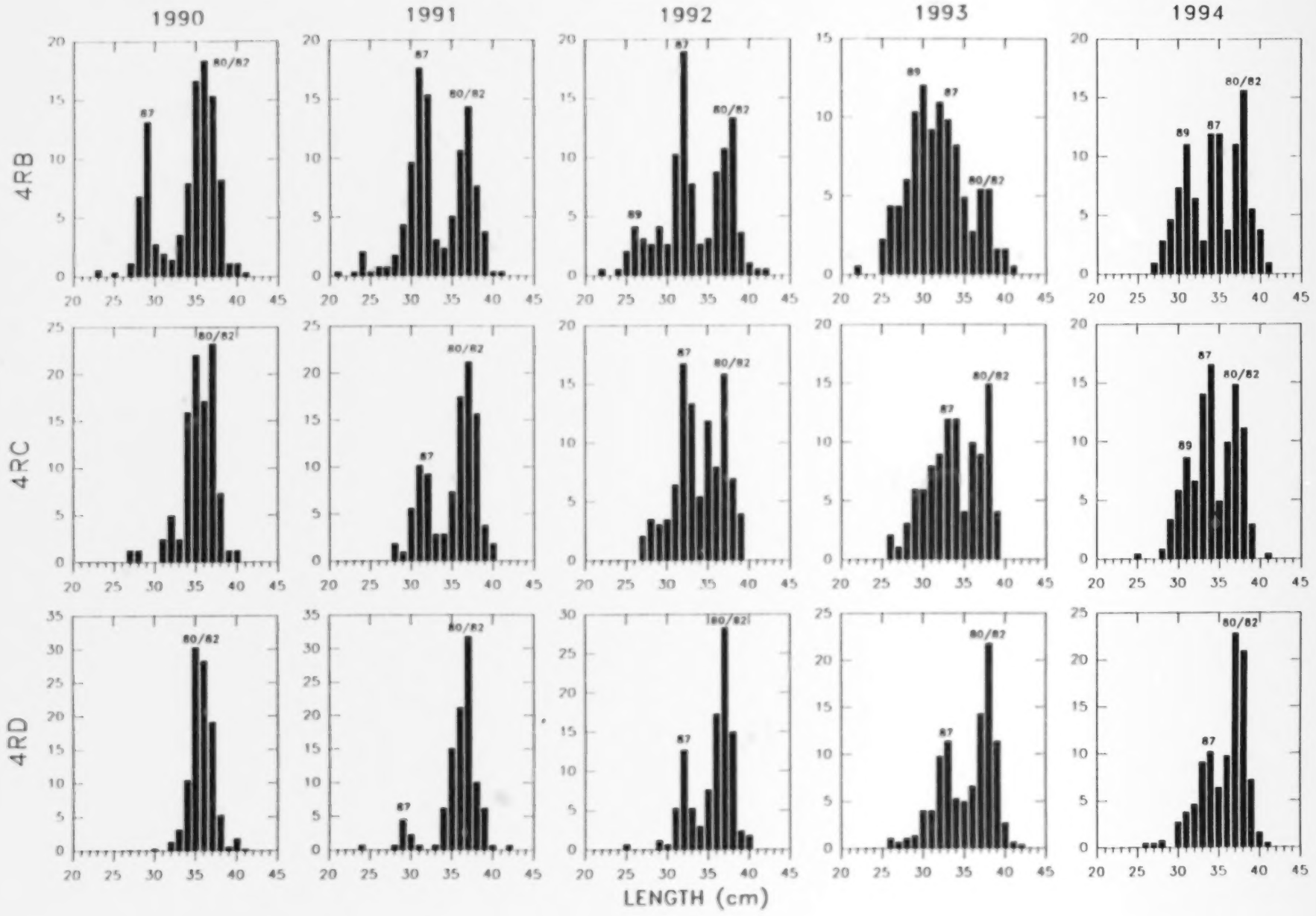


Figure 10. Length frequency distributions of spring–spawning herring by fishing zone and year from large purse seine commercial catches (major year–classes are indicated).

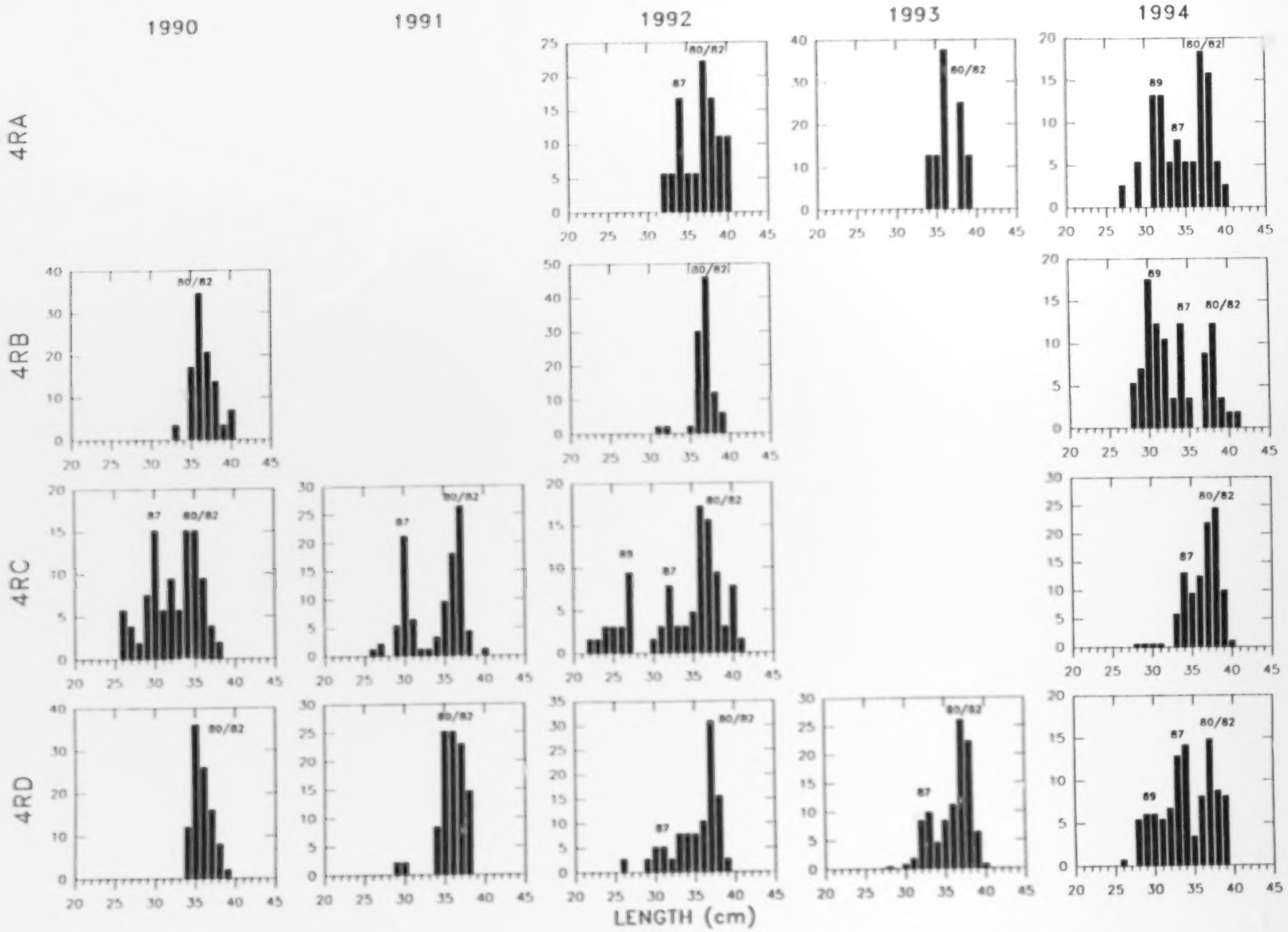


Figure 11. Length frequency distributions of spring–spawning herring by fishing zone and year from small purse seine commercial catches (major year–classes are indicated).

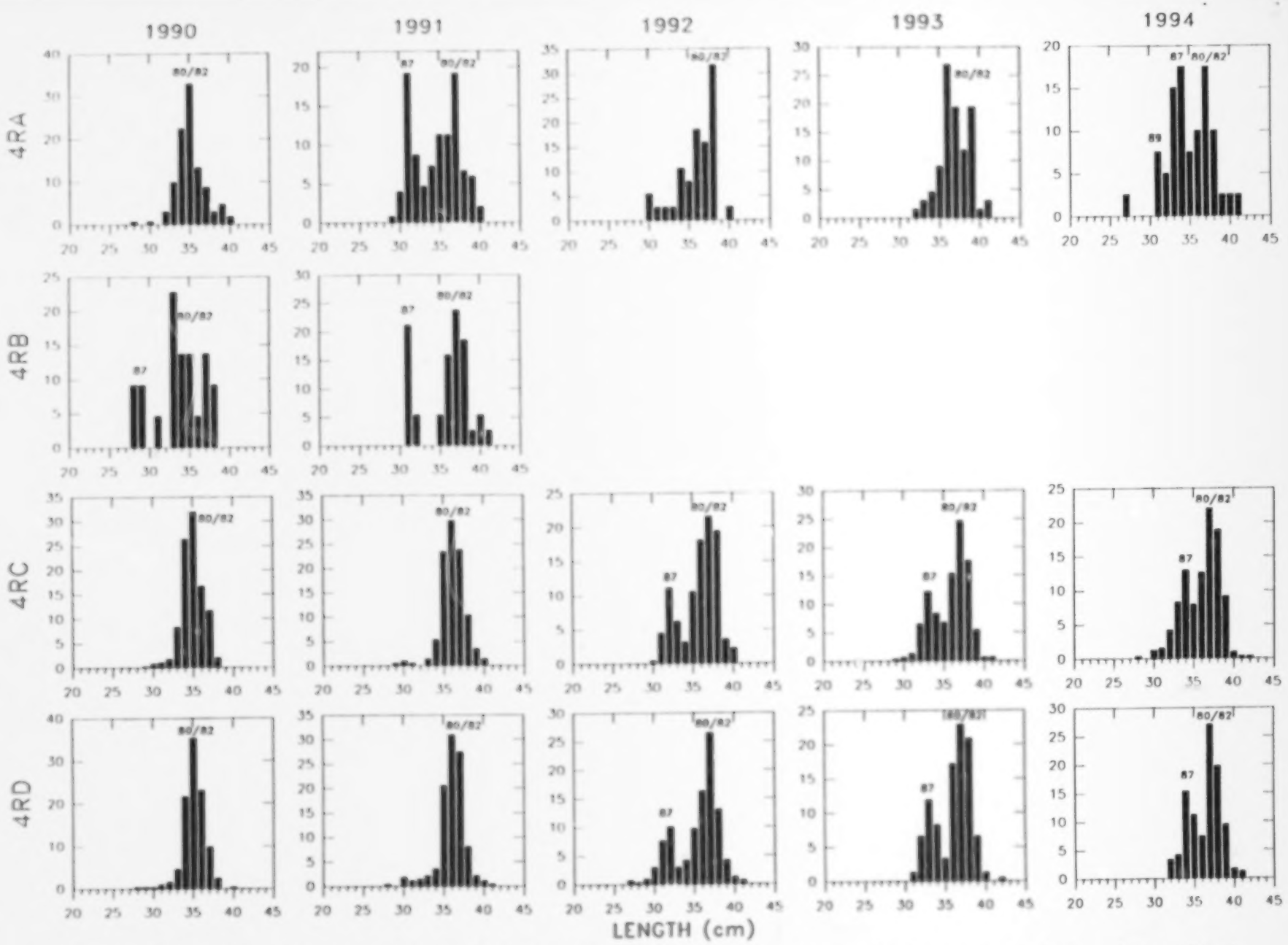


Figure 12. Length frequency distributions of spring–spawning herring by fishing zone and year from gillnet commercial catches (major year–classes are indicated).

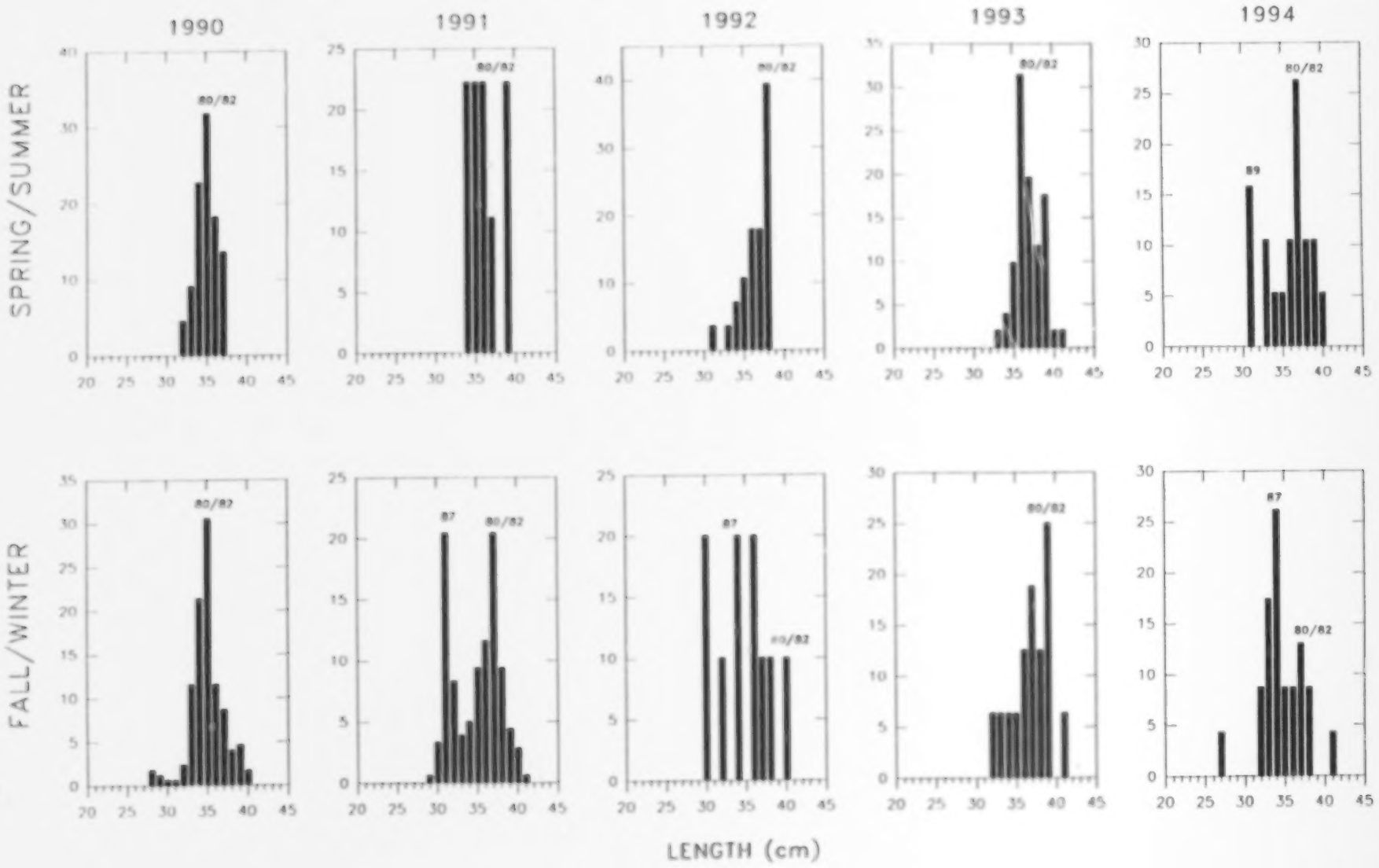


Figure 13. Length frequency distributions of spring–spawning herring by fishing season and year from gillnet commercial catches in fishing areas 4Ra and 4Rb (major year–classes are indicated).

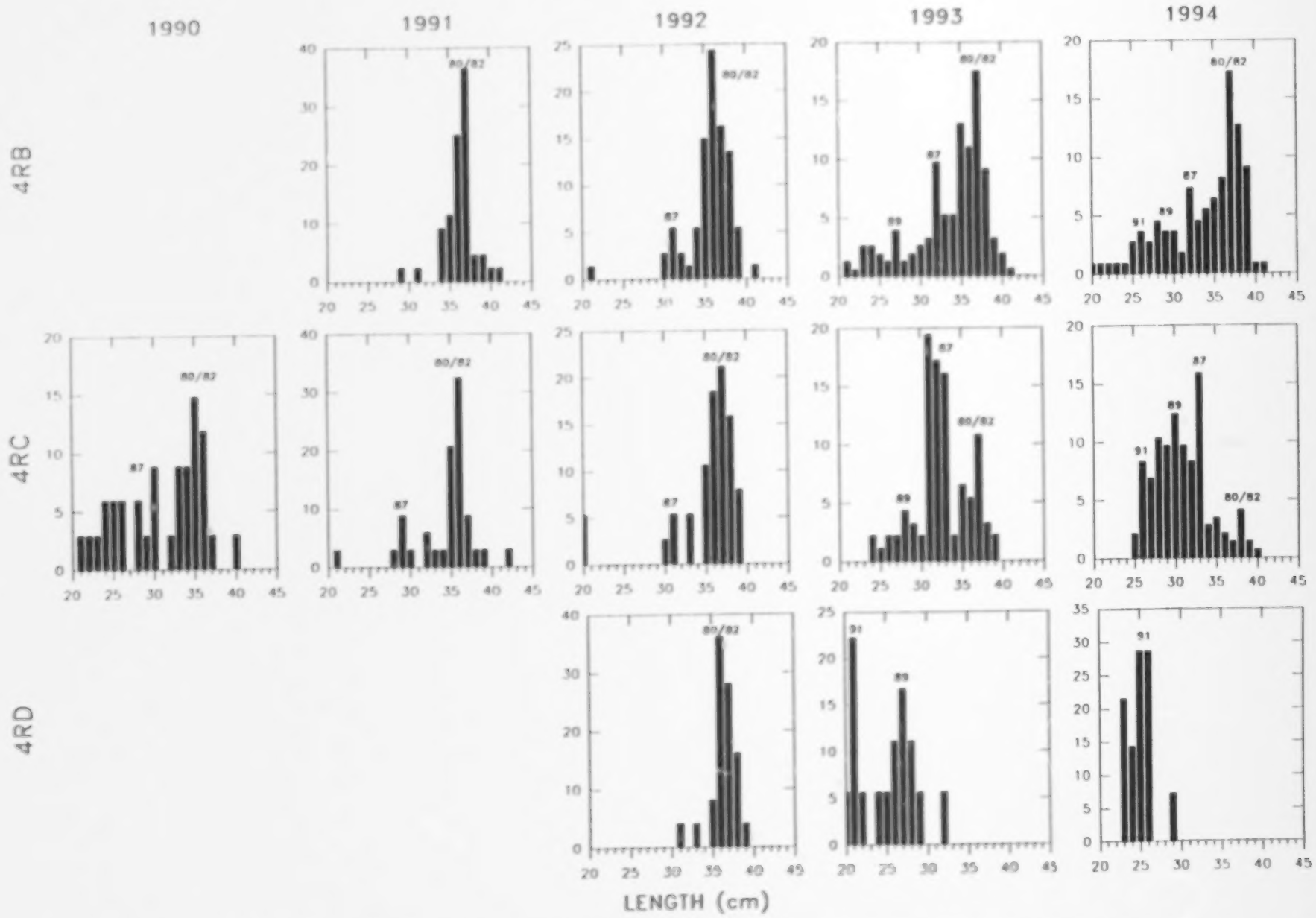


Figure 14. Length frequency distributions of spring-spawning herring by fishing zone and year from the northern Gulf of St. Lawrence January bottom-trawl survey (*Gadus Atlantica*). Major year-classes are indicated.

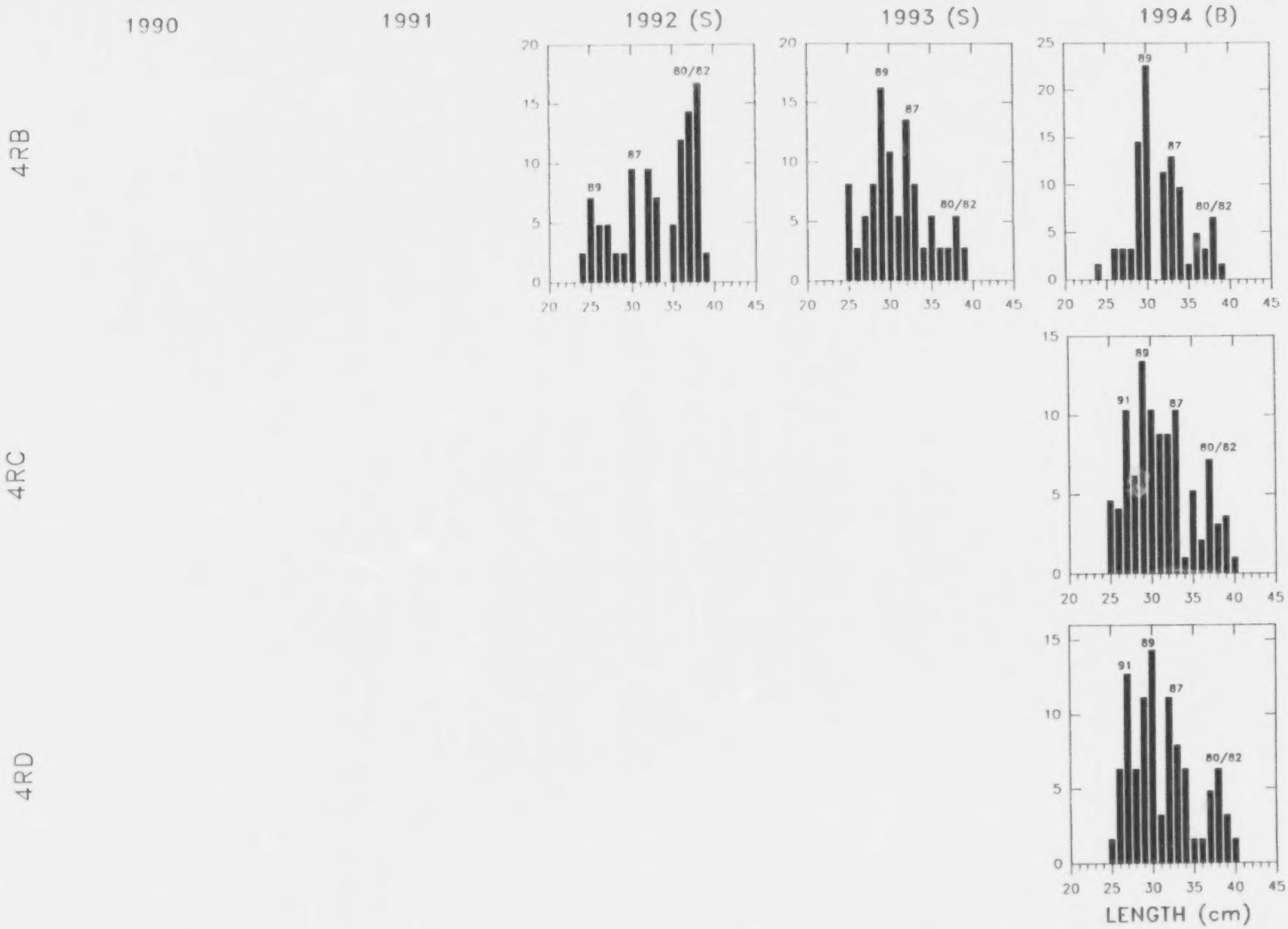


Figure 15. Length frequency distribution of spring–spawning herring by fishing zone and year from shrimp trawl catches (S) and the May bottom–trawl research survey (B). Major year–classes are indicated.

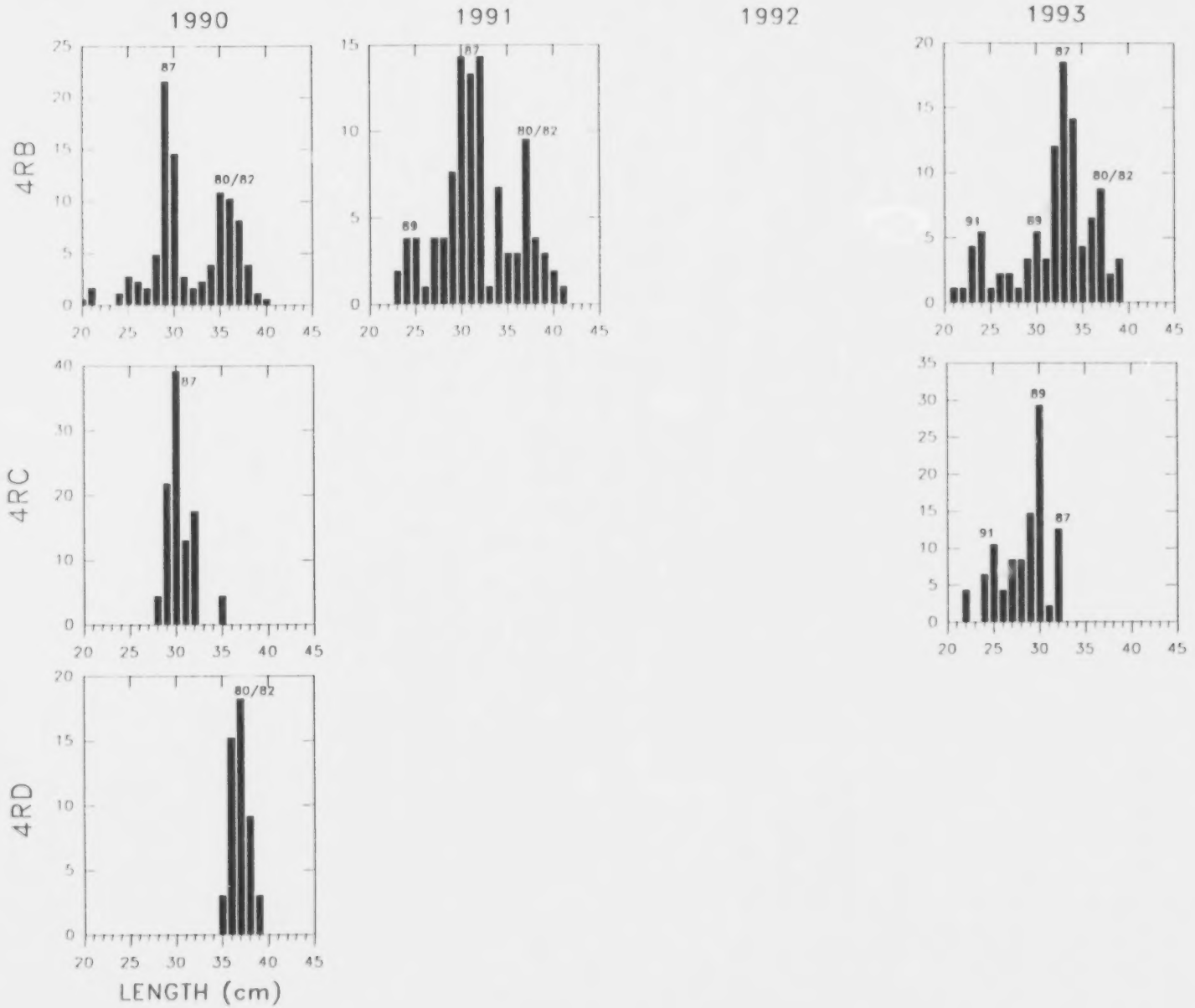


Figure 16. Length frequency distributions of spring–spawning herring by fishing zone and year from the west coast of Newfoundland November acoustic survey (Major year–classes are indicated).

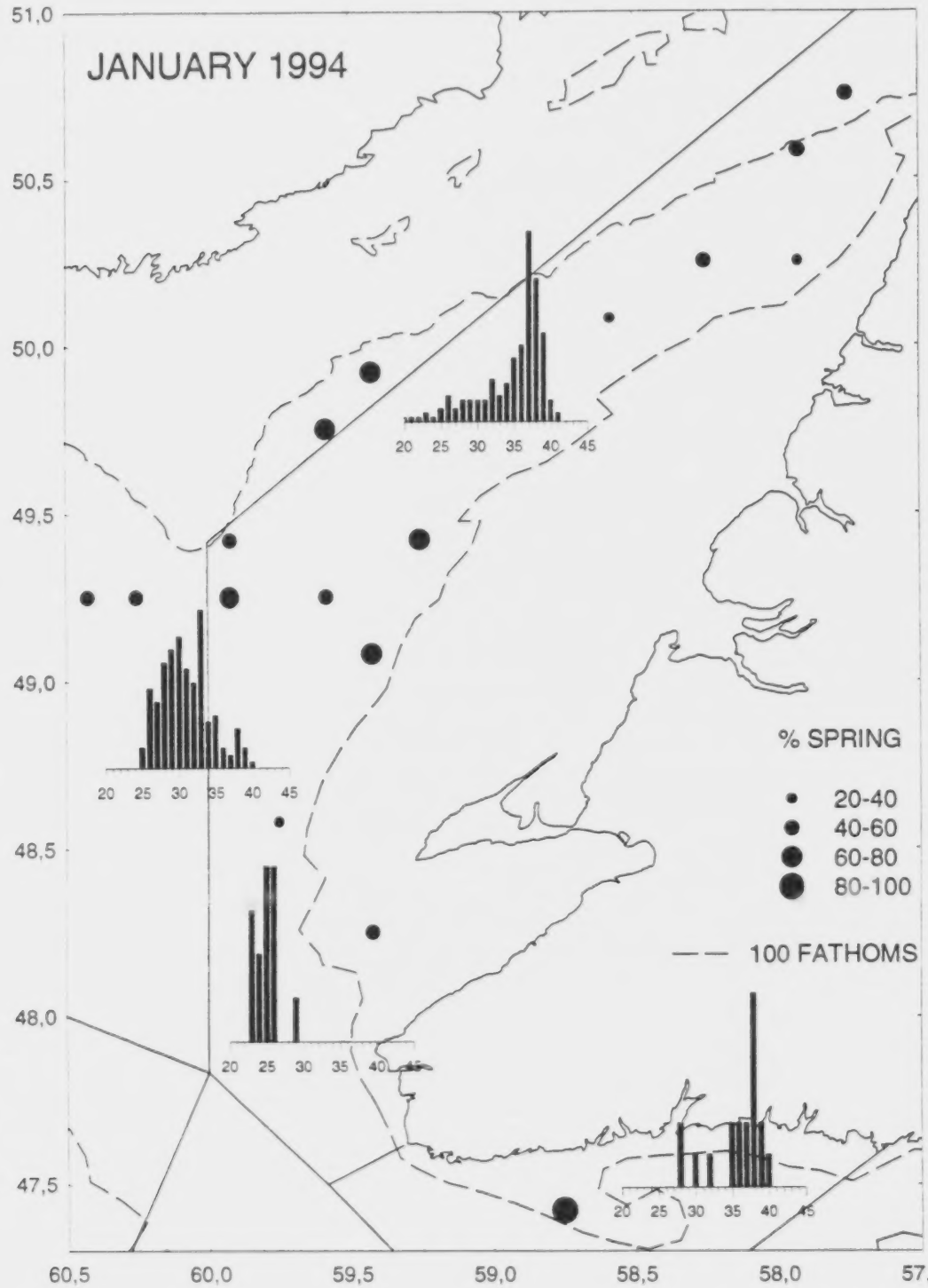


Figure 17. Percent of spring spawning herring by 10 minute squares from the *Gadus Atlantica* bottom-trawl survey in January, 1994, with corresponding length distributions.

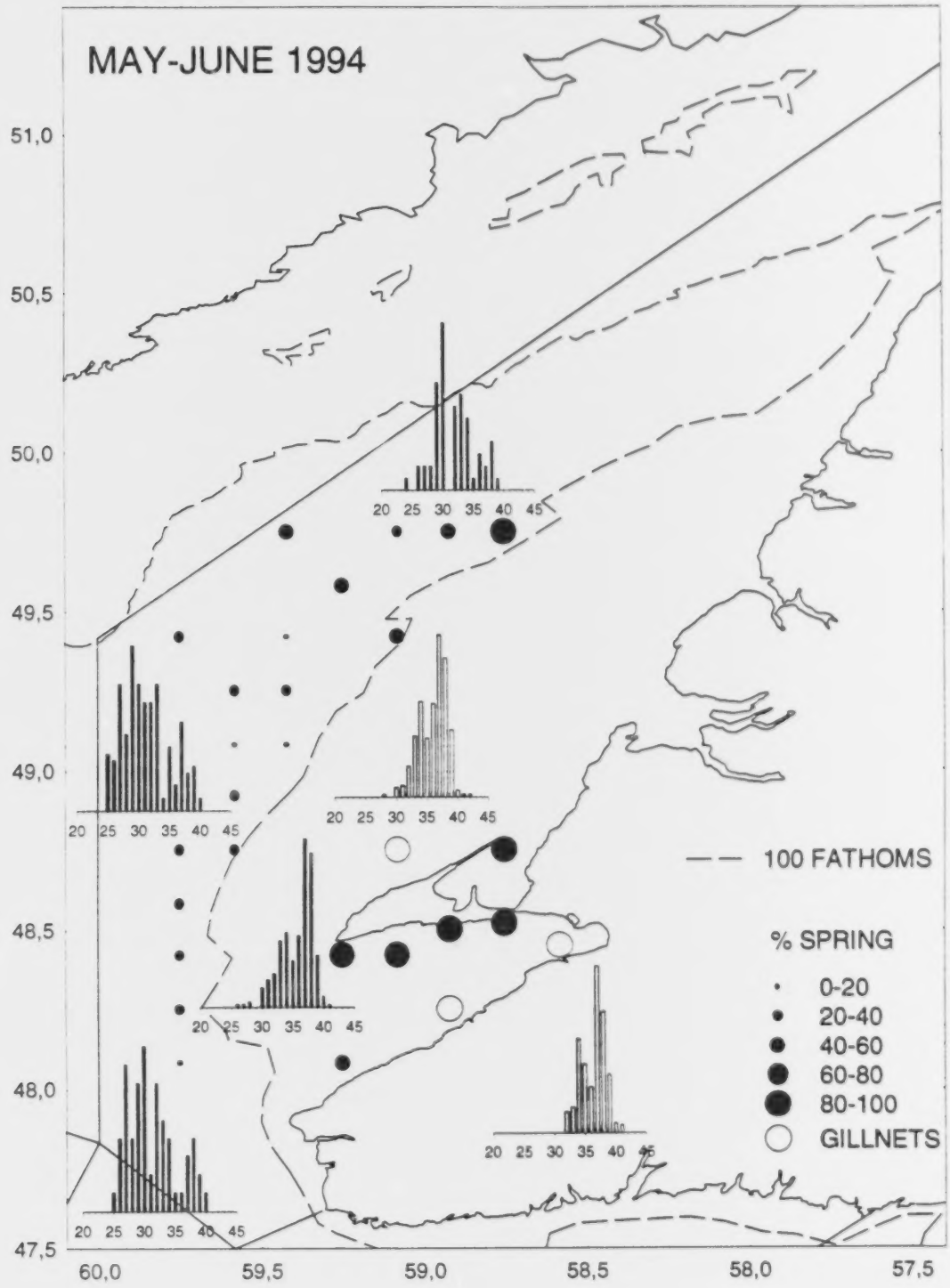


Figure 18. Percent spring spawning herring by 10-minute square for May and June from all commercial and research data collected in 1994 with corresponding length distributions.

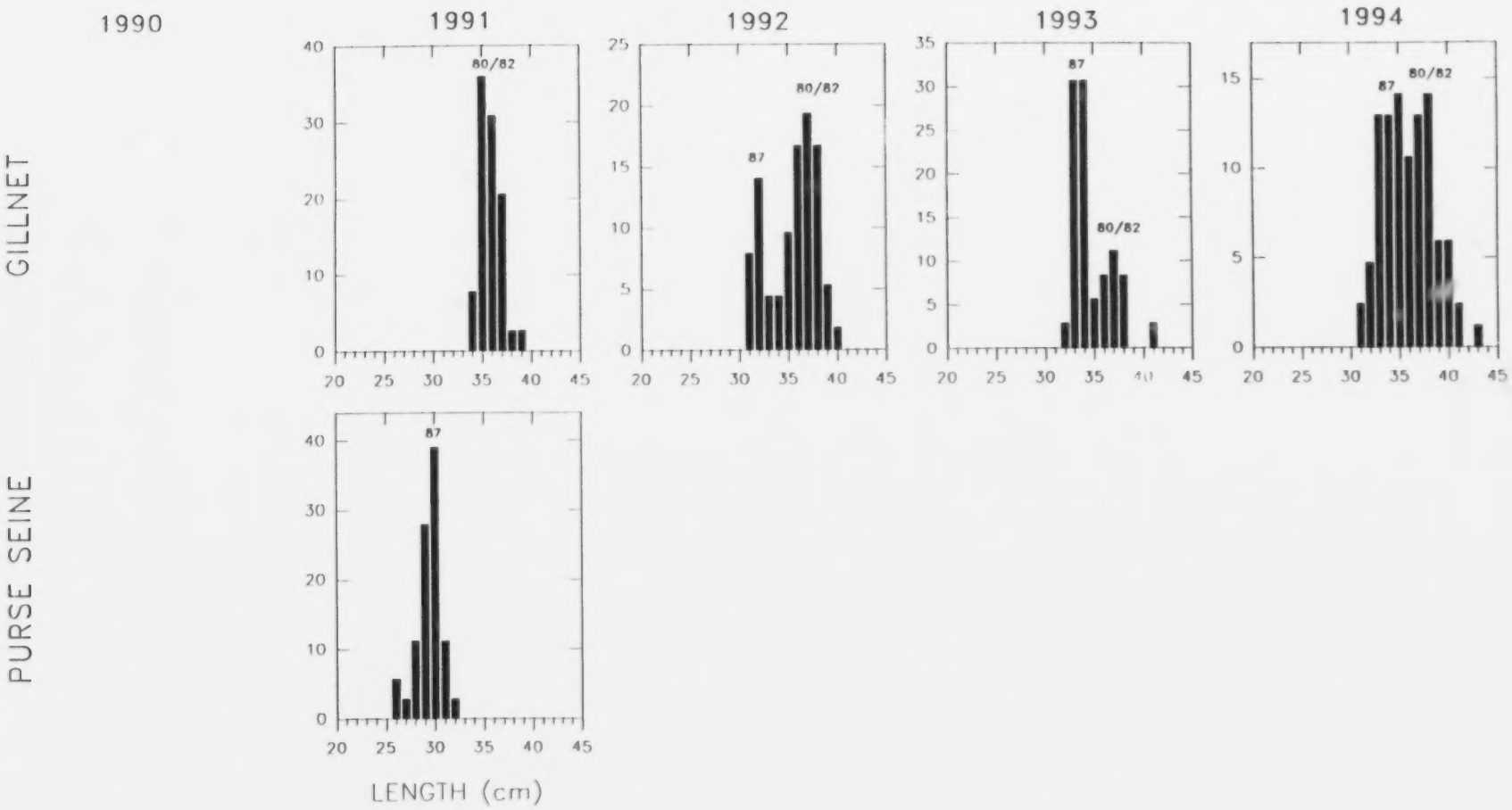


Figure 19. Length frequency distributions of spring-spawning herring by gear and year from along the lower north shore of Quebec (4S). Major year-classes are indicated.

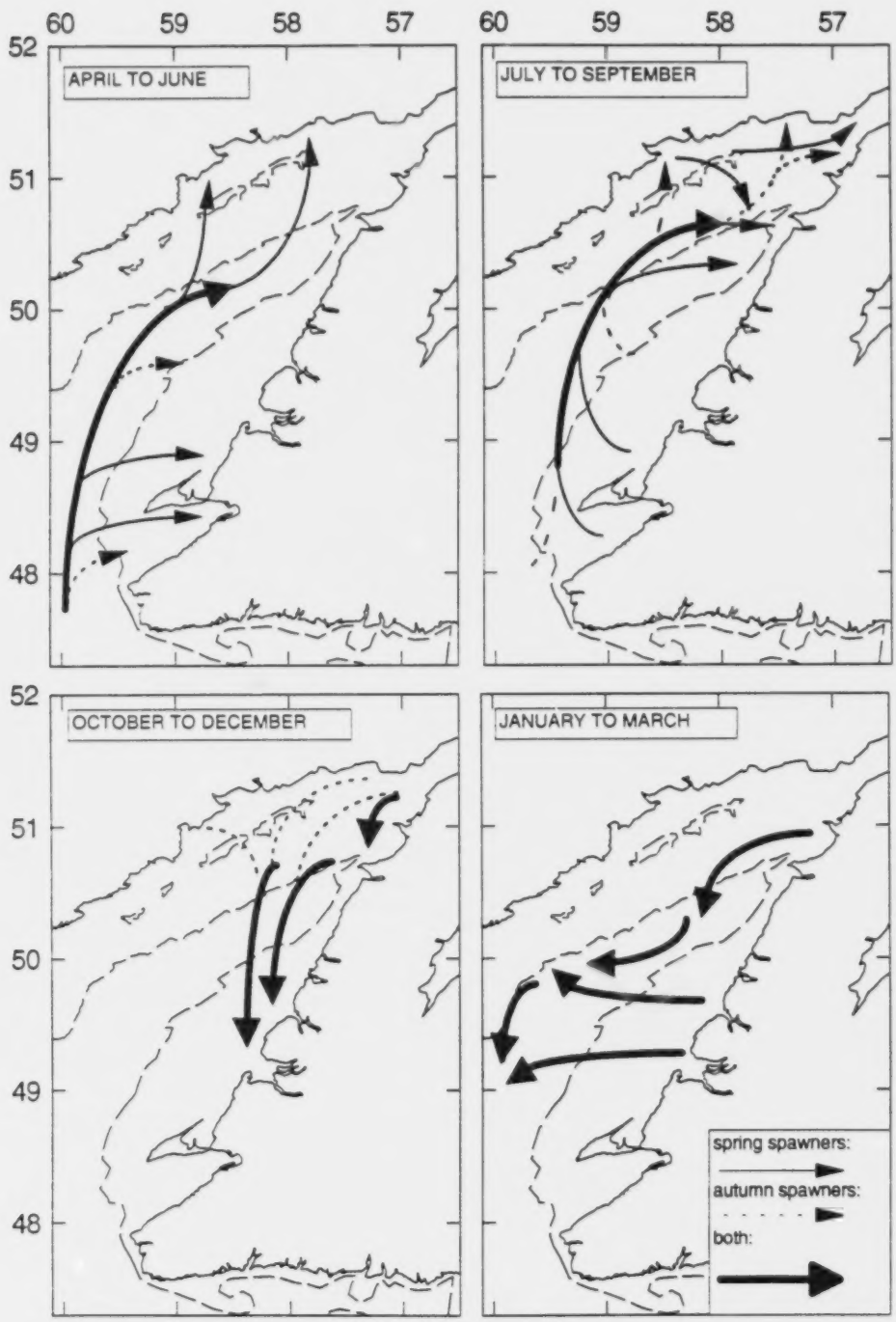


Figure 20. Probable annual migration pattern of spring- and autumn-spawning herring in the north-eastern Gulf of St. Lawrence.